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OPTIMISM AND CARDIOVASCULAR REACTIVITY TO PSYCHOLOGICAL AND COLD PRESSOR STRESS

C. N. LEAKE
A. W. LANGER
C. E. ENGLUND
M. SINCLAIR

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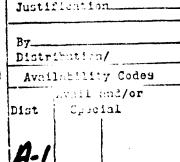PSYCHOLOGICAL AND COLD PRESSOR STRESS

C.N. LEAKE, A.W. LANGER,* C.E. ENGLUND, M. SINCLAIR

Naval Health Research Center
PO Box 85122
San Diego, CA 92138-9174

*Syracuse University
Syracuse, NY 13210

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Summary

The relationship between optimism, as measured by the Life Orientation Test (LOT), and the response to mental arithmetic (MA) and cold pressor (CP) stressors was examined in 35 men. Reactivity measurements included heart rate (HR), systolic (SBP) and diastolic (DBP) blood pressure, oxygen consumption (V), minute ventilation (VE), and plasma cortisol (CORT). In order to clarify the importance of optimism to reactivity, additional assessments were made for hostility, depression, behavior type, and trait anger and anxiety. Both stressors elicited significant cardiovascular, pulmonary and cortisol responses ($P < 0.005$) with the magnitude of response being greater for the CP task. Significant Pearson correlations were found between LOT and CP reactivity for VE ($r = -.285$, $P < 0.05$), and MA reactivity for HR ($r = .281$, $P < 0.05$) and VE ($r = .374$, $P < 0.01$) yet the results suggest that optimism was not strongly associated to reactivity elicited by either stressor. However, results did indicate that the relationship between optimism and cardiovascular reactivity may be as important as those exhibited by other psychological parameters.

2

INTRODUCTION

Recent investigations have begun to explore the possibility that optimism, as a stable personality characteristic (Scheier and Carver, 1985; Scheier and Carver, 1987), may be of beneficial effect upon health. Conversely, cardiovascular reactivity has been implicated as a coronary heart disease (CHD) risk factor (Clarkson et al., 1986; Krantz and Manuck, 1984). The general purpose of the present study was to assess the relationship between optimism and physiological reactivity to psychological stress.

The mechanisms by which optimism affects health, although not clearly defined, are beginning to be explored. Dispositional optimism, as measured by the Life Orientation Test (LOT), (Scheier and Carver, 1985), has been shown to be significantly related to reduced physical symptom reporting (Scheier and Carver, 1985). In addition, more rapid recovery from coronary bypass surgery has been reported for optimists as compared to pessimists (Scheier and Carver, 1987). In this study, the authors also noted that optimists appear to have fewer intraoperative complications.

There is evidence that dispositional optimism is also important to how people regulate their actions and approach problems. Directly associated to this concept is the relationship between optimism and strategies of coping. Results suggest optimists, as opposed to pessimists, automatically use different coping strategies when faced with a stressful situation (Scheier et al., 1986). Findings imply that optimists tend to use strategies that are more adaptive to specific circumstances and least dysfunctional (Scheier and Carver, 1985). Lazarus and Folkman (1984) describe two general ways in which people cope with stressful situations. "Problem-focused" coping centers on attempts to deal with the source of the stress by removing or circumventing the distress, while "emotion-focused" coping seeks to reduce or eliminate the emotional distress associated with the situation. Scheier and Carver (1987) argue that problem-focused coping is more likely among those who expect to get positive results from their actions. Therefore, since optimism is associated with positive outcome expectancies, it follows that optimists would be more likely to utilize problem-focused strategies of coping. Scheier et al., (1986) have, in fact, reported that optimists tend to use

3

problem-focused coping, and concentrate on the positive aspects of the stressful situation while pessimists tend to focus on stressful feelings, and are more likely to disengage themselves from the goal in which the stressor was interfering.

Research results indicate that certain variables, such as the type of stressor, can evoke different strategies. For example, emotion-focused coping is more likely when the stressor must be endured (Folkman and Lazarus, 1980). In this situation, optimists and pessimists can be expected to use different emotion-focused strategies. It has been postulated (Scheier and Carver, 1987) that because optimists rely on acceptance versus denial strategies, they can expect better adjustments to a variety of life difficulties.

Another mechanism that may explain the better health outcomes displayed by optimists may be the magnitude of reactivity to physiological distress that is being experienced. However, to date, no research has been published on the relationship between optimism and physiological reactivity.

Reactivity measurements routinely involve hemodynamic effects such as changes in blood pressure and heart rate, and often include hormonal changes of cortisol and/or catecholamines. Although important to reactivity studies, these variables show promising but inconsistently meaningful relationships to CHD (see review article, Krantz and Manuck, 1984).

When dealing with a psychological trait, such as optimism, it is often impossible to assess only that trait in isolation from others. For example, Scheier and Carver (1987) argue that the health-related aspects of hostility, as measured by the Cook-Medley Hostility scale (Ho), may indeed be due to an underlying relationship to optimism. In addition, it has been argued that only some of the aspects of Type A behavior are important to the increased risk of CHD (Matthews et al., 1977). Similarly, the role of anger and hostility to stress-induced cardiovascular responses is not clear (see review article, Houston, 1983). For these reasons, it was important to the present study to attempt control over many of the psychological variables that have been associated with either physiological reactivity or optimism.

4

The major purpose of this study was to assess the relationship between optimism and physiological reactivity to both an active psychological stressor [mental arithmetic (MA)] and a passive physical stressor [cold pressor (CP)]. Additionally, it was important to control for a number of psychological attributes so that the relationship between optimism and reactivity was less obscure. Both MA and CP tasks were chosen because both have been widely used as laboratory stressors (e.g., Turner et al., 1986; Zbrozyna and Krebbel, 1985). Due to their averse characteristics, both stressors have been shown to elicit significant cardiovascular responses.

METHODS

Subjects

The volunteer subjects were 50 males ranging in age from 18 to 35 years with a mean of 27.2 years. All subjects were apparently healthy, and were not taking any counter-indicative medications. In addition, all individuals had a medical history free of cardiovascular heart disease and normal resting blood pressures (< 140/90).

Preliminary statistical analyses compared the reactivity of subjects with a negative family history of hypertension to those who had either a positive family history of hypertension or who had parents with complicated essential hypertension. Because the two groups did not significantly (P < 0.05) differ in any of the reactivity variables measured, they were combined into one study group for further analyses.

Subjects were instructed to abstain from recreational drugs at least 48 hours before coming to the lab. In addition, no eating or caffeine ingestion was permitted for at least 12 hours before testing. Strenuous exercise was prohibited for a 24-hour period before scheduled testing.

Procedures

Informed consent was followed by completion of a medical background questionnaire. A standard 12-lead electrocardiogram (ECG) was performed.

5

Immediately following the ECG, an indwelling catheter was placed in, or near, the antecubital space of one forearm. Arm selection was chosen randomly among subjects. At least 30 minutes (min) passed before the subject was taken to either the cold pressor or mental arithmetic station. During this time, the subject filled out a background questionnaire and psychological paper and pencil tests.

In random order, the subjects then went to either the cold pressor or mental arithmetic station. After both tasks were completed, the indwelling catheter was removed. Measurements took place between 10:00 am and 4:00 pm.

Cold Pressor (CP). The CP task involved submersion of the right foot, to a level approximately 3-4 inches above the ankle, into a $4^{\circ}C$ water bath for 60 seconds (sec). The task was preceded by a minimum 5-min baseline, and followed by a 10-min recovery period, during which time, metabolic parameters were measured and recorded. The baseline period was contingent upon the determination of steady-state conditions for metabolic parameters. During the baseline and recovery periods, the exposed foot was resting outside the water bath. Heart rate and blood pressure were measured with an automatic sphygmomanometer, and recorded every minute. Volume of oxygen consumption and expired air were recorded breath-by-breath using a Sensormedics Horizon 4400 metabolic cart.

Mental Arithmetic (MA). A 6-min MA task was performed on an IBM-AT computer. The task involved a 3-sec presentation of an addition or subtraction problem followed by a 3-sec response time in which the subject had to decide on one of four multiple choice answers presented on the computer. The program was designed so the degree of difficulty changed directly proportional to the performance level of the subject. At the 2-min and 4-min marks, the subject was asked to speed up the response time, and be more accurate. The task was preceded by a minimum 5-min baseline, determined as in the CP task, and followed by an 8-min recovery period. Heart rate and blood pressure were measured by a Dinamap TM Vital Sign Monitor (Model 845) at 1-min intervals, oxygen consumption and ventilation as in the CP task.

Blood draws. A heparin-lock procedure was used to minimize the effects of the blood draw experience. The heparin concentration in the line was 1 unit/1000 units of normal saline solution. Blood draws were taken during both the MA and CP tasks, and consisted of 20 ml samples taken at three different times. The first was taken at the end of a stable 5-min baseline period. The second draw was taken immediately after the task, and the final draw after the recovery period.

The blood samples were collected in refrigerated collection tubes and cold centrifuged for 20 min. The plasma was separated and stored at -80°C until analyzed for cortisol. The assay for cortisol was performed on the Abbott TDx system using fluorescence polarization immunoassay technology.

Reactivity measurements. Reactivity was determined by the difference between the task and baseline values for all measured metabolic parameters. The baseline value was the mean of five successive 1-min interval measurements taken just prior to the first blood draw. The CP procedure had only one task measurement, ending at removal of the foot from the cold water bath. For the MA procedure, the task value was the mean of six measurements. In this way, there were a total of five reactivity measurements for both the CP and MA tasks, systolic blood pressure (CPS, MAS), diastolic blood pressure (CPD, MAD), heart rate (CPHR, MAHR), oxygen consumption (CPV, MAV), and minute ventilation (CPVE, MAVE). In addition, two cortisol reactivity measures were used. Both the recovery (CORT-R) and task (CORT-T) samples were compared to the baseline sample.

Background Questionnaire. A Family History of Hypertension Questionnaire was used to assess both personal and family histories of coronary heart disease, hypertension, stroke, and diabetes.

Psychological Questionnaires. The Life Orientation Test (LOT), (Scheier and Carver, 1985), is a 12-item scale designed to assess dispositional optimism. The Cook-Medley Hostility scale (Ho), (Cook and Medley, 1954), is a 50-item scale designed to measure hostility. The 50-item Beck Depression Inventory (BDI), (Beck, 1967), scale measures depression levels. The Spielberger Trait Anger (Anger) and Anxiety (Anxiety) scales were selected

for use from the state-trait personality inventory (Spielberger, 1970). A measure of Type A behavior (Type) was obtained using the 10-item Framingham Activity Survey (Haynes et al., 1978).

Exit Questionnaire. This seven-item form was designed specifically for this study. It asked the subject to describe, in his own words, what, if any, strategies were used to cope with the discomfort of the cold pressor task. It also assessed techniques generally used when faced with other stressful situations. Depending on responses, the subjects were categorized into either "acceptance" or "denial" coping groups. "Acceptance" was operationally defined as the tendency to focus on the task. These subjects would either attempt to control their heart rate or breathing, or concentrate on the sensation being experienced. "Denial" would include subjects who used disengagement methods, choosing relaxation, blocking, or dissociation as coping strategies. Subjects who described multiple techniques that could be classified into both groups were excluded from analyses comparing these groups.

Statistical Analyses. Repeated measures multivariate analysis of variance (MANOVA) was used to analyze the reactivity variables change from baseline, end of task, and recovery. The Bonferroni technique was used to protect against a Type I error. Because 12 MANOVAs were calculated, an alpha level of 0.005 was selected. Independent t-tests were used to assess the significance of post hoc differences. The relationships between the reactivity variables and psychological assessment variables were analyzed using Pearson product-moment correlations and step-wise multiple linear regression using an alpha level of 0.05. For each reactivity variable, the LOT predictor was forcibly entered after all other predictors were entered as a 'block' of variables. In this way, the amount of variance attributable to optimism, in isolation after control for all other predictors, was obtained. Finally, t-tests between the acceptance and denial coping groups were performed for all variables using an alpha level of 0.05.

8

RESULTS

Table 1 summarizes the characteristics of the population sample for both the criterion and predictor variables. All criterion variables had wide variability with negative values indicating a decreased response to the task. For all criterion variables, the magnitude of reactivity was greater during the CP task.

TABLE 1. MEANS, STANDARD DEVIATIONS, AND RANGES OF SUBJECTS (n = 50)

Variable	Mean (Standard Dev.)	Maximum / Minimum
Background Variables		
Age (yrs)	27.2 (5.07)	35.0 / 18.0
Height (cm)	178.5 (6.43)	193.0 / 163.8
Weight (kg)	79.7 (11.31)	115.7 / 59.4
Resting SBP (mmHg)	120.8 (9.98)	138.0 / 91.8
Resting DBP (mmHg)	75.8 (9.86)	92.6 / 53.2
Resting HR (bpm)	59.3 (9.08)	79.6 / 41.6
Dependent Variables		
CPS (mmHg)	18.2 (12.06)	48.8 / - 8.0
CPD (mmHg)	11.4 (13.28)	50.0 / - 14.8
CPHR (bpm)	13.0 (14.53)	53.2 / - 13.2
CPV (ml O2/min)	158.3 (135.62)	879.4 / 19.4
CPVE (1 air/min)	6.6 (11.83)	78.0 / - 0.3
CPCORT-T (ug/dL)	- 0.30 (1.41)	3.1 / 3.3
CPCORT-R (ug/dL)	2.4 (3.59)	11.1 / 4.9
MAS (mmHg)	9.4 (8.69)	27.7 / - 14.7
MAD (mmHg)	3.0 (5.33)	15.9 / - 9.8
MAHR (bpm)	9.3 (7.25)	32.2 / - 2.5
MAV (ml O2/min)	56.3 (50.62)	231.5 / - 27.6
MAVE (1 air /min)	2.7 (2.03)	9.0 / - 3.2
MACORT-T (ug/dL)	0.09 (2.16)	8.2 / 4.3
MACORT-R (ug/dL)	0.52 (2.80)	7.3 / 4.7
Independent Variables		
LOT	21.7 (4.48)	29.0 / 10.0
Ho	20.2 (6.65)	35.0 / 5.0
BDI	4.9 (5.84)	31.0 / 0.0
ANGER	19.2 (5.11)	35.0 / 11.0
ANXIETY	18.6 (4.36)	29.0 / 10.0
TYPE	5.5 (1.74)	8.0 / 1.0

MANOVA results indicate that both stressors elicited significant cardiovascular (SBP, DBP, HR, and VO_2), pulmonary (VE), and cortisol responses ($P < 0.005$) above baseline values.

Table 2 displays the Pearson correlation co-efficients between the reactivity and predictor variables. LOT was significantly correlated to the minute ventilation changes of both stressors and the MA heart rate response ($P < 0.05$ for CPVE and MAHR, $P < 0.01$ for MAVE). Beck depression values were related to systolic blood pressure reactivity of both stressors and the diastolic reactivity of the CP stressor ($P < 0.05$). Task cortisol reactivity was significantly correlated only to the Type A measure ($P < 0.01$); the recovery cortisol measure had no significant correlations. In addition, Type A scores were significantly correlated to MA oxygen consumption and minute ventilation ($P < 0.05$) changes. While CP heart rate reactivity had no significant correlations, the MA measure was significant to LOT, anxiety, and weight measures ($P < 0.05$). Weight was also important to CP diastolic reactivity ($P < 0.05$).

For the CP stressor, all significant correlations were negative. Conversely, for the MA stressor, the correlations for the same relationships were either significantly positive, or had a tendency in the positive direction. Similarly, with the exception of heart rate, significant correlations for the MA stressor corresponded to tendencies in the opposite direction for the CP task. As an example, the correlations between LOT and CPVE and MAVE were -.285 and .374, respectively.

Table 3 indicates that the significant relationships between minute ventilations (CPVE and MAVE) and LOT remain significant when the other predictor variables were controlled using multiple regression. However, controlling for the other predictors also results in a significant change in R squared for CPV [$F(7,26) = 5.16$, $P < 0.05$]. The significant correlation between LOT and MAHR was lost when other predictors were controlled.

When the subject population was divided into acceptance and denial coping groups two, significant differences were found. During the CP task, both

10

systolic and diastolic blood pressures were more reactive in the acceptance group [t(38)=2.11, P < 0.05 and t(37) = 3.17, P < 0.01, respectively].

TABLE 2. PEARSON CORRELATION COEFFICIENTS BETWEEN REACTIVITY AND SELECTED PREDICTORS

	Predictor							
Reactivity	LOT	Ho	BDI	ANGER	ANXIETY	TYPE	AGE	WEIGHT
CPS	.059	- .236	- .329*	.083	- .169	- .157	.115	- .146
CPD	.247	- .082	- .268*	.131	- .200	- .109	.030	- .264*
CPHR	- .023	- .111	.013	.092	.125	.102	.032	.031
CPV	- .214	- .233	- .183	.040	- .108	- .103	.102	- .215
CPVE	- .285*	- .147	- .026	.024	- .019	- .012	.085	- .208
CPCORT-T	- .019	- .028	- .188	- .112	- .043	- .370**	- .028	- .207
CPCORT-R	- .085	- .019	- .233	.033	.103	- .202	.037	- .161
MAS	.078	.016	.299*	.108	.176	.064	.077	.189
MAD	.084	.067	.086	.204	.007	.175	- .024	.212
MAHR	.281*	- .063	- .179	.029	- .242*	.125	.070	.289*
MAV	.174	.116	.084	- .074	- .060	.240*	.018	.147
MAVE	.374**	- .002	.096	- .075	- .016	.259*	.072	.194
MACORT-T	.067	.233	.078	.194	.025	.142	.016	.178
MACORT-R	.054	.230	- .133	.223	.047	.070	.023	.146

* P < 0.05, ** P < 0.01

TABLE 3. REGRESSION R SQUARED CHANGE, MULTIPLE R, AND ADJUSTED R SQUARED FOR BLOCKED MULTIPLE REGRESSION

Variable	R Squared Change	F Change	Multiple R	Adjusted R Squared
CPV	.138	5.16*	.553	.119
CPVE	.188	7.03*	.551	.116
MAVE	.168	6.62*	.585	.165

* $P < 0.05$

DISCUSSION

The results of this study suggest that optimism, as measured by the LOT, is not strongly associated to reactivity elicited by psychological or cold pressor stress. Although the association between optimism and both oxygen consumption and minute ventilation changes were significant and stable (Table 3), these parameters are not commonly measured in reactivity studies. In addition, the magnitude of relationships between any of the criterion and predictor variables are weak at best. Even for one of the strongest relationships found, optimism explains less than 14% of the variance in MAVE. However, results do indicate that the relationship between optimism and physiological reactivity may be as important as relationships exhibited by other psychological parameters.

Regression results (Table 3) suggest stable relationship between optimism and both CPVE and MAVE. However, the correlations between these variables were opposite in direction. Possible explanations include the potential for optimism to help prepare an individual for the discomfort of the CP task. It is feasible that, depending on level of anticipation and expectation, being optimistic of one's performance can help prevent or minimize hyperventilation during the CP task. Conversely, the positive relationship between the MAVE and optimism may reflect a 'disappointment' response. The sense of failure may be more devastating for the optimist because of higher initial

12

expectations to do well. During the CP test, the optimist can immediately tell that the task is tolerable, and draw strength from that feeling. However, during the MA task, a sense of failure may rapidly arise. Therefore, the optimist may have a greater sense of failure because of the greater initial positive outcome expectancy.

Another potential explanation for the opposite relationship between optimism and the ventilatory responses to the CP and MA stressors is task specificity. To explore this possibility, the reactivity to the CP and MA task were compared. Table 4 reports the t-test values and correlation coefficients for comparison between the MA and CP tasks. Systolic and diastolic blood pressures and oxygen consumption reactivity had the greatest significant differences between the two tasks ($P < 0.001$). No significant differences were found between the stressors for either heart rate reactivity or the baseline to task cortisol samples. Moreover, significant negative correlations were observed for SBP ($r = -.347$, $P < 0.05$), VE ($r = -.384$, $P < 0.01$) and task cortisol ($r = -.363$, $P < 0.05$) reactivity. In conjunction with the extreme variances found in all reactivity measures, these results indicate that the response to a particular task is highly individualistic.

TABLE 4. T-TEST AND PEARSON CORRELATION COEFFICIENTS
BETWEEN MA AND CP STRESSORS

Reactivity Variable	t	r
Systolic Blood Pressure	3.50 ***	- .347 *
Diastolic Blood Pressure	3.96 ***	.026
Heart Rate	1.56	.026
Oxygen Consumption	4.38 ***	- .212
Minute Ventilation	2.07 *	- .384 **
Task Cortisol	- 0.96	- .363 *
Recovery Cortisol	2.10 *	- .104

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

This study supports the principle that different patterns of physiologic responses can be expected when tasks being used have different behavioral demands. Because the MA was an active psychological task, sympathetic influences on the cardiovascular system would be expected. As a passive physical stressor, the CP task would be expected to elicit greater DBP increases and smaller SBP and HR changes (Obrist et al., 1978). These expectations were not totally realized in this study. However, differences in the associations with psychological predictors enforces the principle of task specificity. For example, assuming it is advantageous to have decreased reactivity to do well on the CP task, a subject would have tendencies toward optimism, depression, and Type A behavior. Conversely, to do well on the MA task the subject would be pessimistic, have low levels of depression, have high trait anxiety, and exhibit Type B behavior. Of course, this characterization is greatly oversimplified, but does illustrate the importance of using at least two different types of stressors to evaluate reactivity.

The importance of task specificity, individual inconsistencies in reactivity, and wide variances in response, illustrates a potential source for erroneous conclusions when trying to characterize reactivity to stress. To be optimistic may be beneficial to a number of health-related outcomes (Scheier and Carver, 1987), but it may be inappropriate for some psychosocial situations that can elicit physiological reactivity. To reduce reactivity, it may be advantageous for an individual to apply one of many psychological coping strategies to a given situation.

Results from the comparison between the acceptance and denial groups also imply the importance of task specificity. Results suggest that individually-practiced coping strategies do not affect reactivity outcomes during the MA task. Conversely, coping strategy seems to affect blood pressure reactivity during the CP task. Apparently, the acceptance group was less successful dealing with a task that allowed voluntary cognitive attention. Therefore, these findings support the premise that demands of the task are important to coping strategy effectiveness (Lazarus and Folkman, 1984).

In conclusion, optimism does not appear to be significantly related to commonly measured reactivity parameters. Being optimistic may attenuate the response to the CP task, but may elicit greater reactivity to the MA task.

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